AIR QUALITY STUDY OF A STEEL CITY ROURKELA , ORISSA

Bachelor of Technology (B. Tech)

In

Civil Engineering

By

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Under the guidance of

Prof. K.K.Paul

Certificate of Approval

This is to certify that the thesis entitled **AIR QUALITY OF A STEEL CITY, ROURKELA, ORISSA** submitted by **Mr. Mayank Saxena** has been carried out under my supervision in partial fulfillment of the requirements for the Degree of **Bachelors of Technology** (**B. Tech**) in **Civil Engineering** at National Institute of Technology Rourkela, and this work has not been submitted elsewhere before for any other academic degree/diploma.

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AIR QUALITY STUDY OF A STEEL CITY ROURKELA (ORISSA)

ABSTRACT

The iron and steel industry is an important basic industry because of high demand of iron and steel utilization, and the production process necessarily produces a significant volume of dust as well as gaseous effluents. An air quality monitoring program has been designed to collect the gaseous and particulate air pollutants from two sites (in front of Indira Gandhi Park & Udit Nagar) of the steel city, Rourkela. The PM_{10}, TSP and gaseous air pollutants sulfur dioxide (SO_2), nitrogen dioxide (NO_2),ammonia (NH_3) &carbon monoxide (CO) will be measured by high volume sampler .The average SO_2,NO_2,NH_3,CO,PM_{10} and TSP concentration at Uditnagar (Residential site) during weekdays are 0.0155ppm, 0.3396ppm, 0.5119ppm, 0.70ppm, 24.50 µg/m^3 and 158.38µg/m^3 respectively. The average SO_2, NO_2, NH_3, PM_{10} & TSP concentration at Uditnagar during weekends are 0.0179ppm, 0.2302ppm, 0.3238ppm, 0.75ppm, 8.57µg/m^3 and 159.49µg/m^3 respectively. The average SO_2, NO_2, NH_3, PM_{10} & TSP concentration at Indira Gandhi Park (Industrial site) during weekdays are 0.0198pm, 0.2701ppm, 0.6744ppm, 0.54ppm, 17.76µg/m^3 and 169.41µg/m^3 respectively. The average SO_2, NO_2, NH_3, PM_{10} & TSP concentration at Indra Gandhi Park weekends are 0.0193ppm, 0.2807ppm, 0.7847ppm, 0.24ppm, 22.81µg/m^3 and 156.46µg/m^3, respectively.

Keywords*:* air quality, steel city, particulate matter, gaseous pollutant

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Rapid industrialization & urbanization has resulted in the emergence of industrial centers that results in increase in pollution level of the air .The air we breathe is a mixture of gases and small solid & liquid particles. In India, pollution has become a great topic of debate at all levels and especially the air pollution because of the enhanced anthropogenic activities Among the harmful chemical compounds, of fossils fuels burning puts into the atmosphere, are carbon dioxide (CO_2), Carbon monoxide (CO), Nitrogen oxide (NO_X), Sulfur Dioxide (SO_2) and tiny solid particles –including lead from gasoline additive called particulate. Some substances come from natural sources while others are caused by human activities. Air pollution occurs when the air contains substances in quantities that could harm the comfort or health of humans and animals, or could damage plants and materials. These substances are called air pollutants and can be either particles, liquids or gaseous in nature (Alias, M. et.al., 2007)[4]. Particulate matter and gaseous emissions of pollutant emission from industries and auto exhausts are responsible for rising discomfort, increasing airway diseases and deterioration of artistic and cultural patrimony in urban centers (Rao, M. et.al., 2003)[21]. As many cities around the world become more congested, concerns increase over the level of urban air pollution being generated and in particular its impact on localized human health effects such as asthma or bronchitis. The more this relationship is understood, the better chance there is of controlling and ultimately minimizing such effects. In the majority of the developed world, legislation has already been introduced to the extent that local authorities are required by law to conduct regular Local Air Quality Reviews of key urban pollutants (Ghanem, M. et.al., unknown)[11].

Rourkela is one of the most important industrial cities in the state of Orissa, India. The entire Industrial Complex is divided by a hill range and the hill is virtually a separation boundary between the localities of the steel township and the "Old Rourkela". Steel Township contains various residential sectors and very well planned to protect the inhabitants from environmental pollution. On the other side of the hill range lies Bondamunda area, Civil township, the Giant Steel Plant, several medium industries, like cement, refractories, sponge iron plant, explosive and chemicals and many more small scale industries. For the Steel plant, the raw materials like coal, hematite, limestone, dolomite etc. are available within a short radius of the plant itself. Besides these, bulk of raw materials comes from its own captive mines. A survey from the regional transport office revealed that more than 1.5 lakh registered small and heavy vehicles are in the industrial complex (Naik S., 2005)[17].

1. 2 CLASSSIFICATION OF AIR POLLUTANTS

The air pollutants can be classified as primary or secondary pollutants. The primary air pollutants are harmful chemicals which directly enter the air due to natural events of human activities. Secondary air pollutant is a harmful chemical produced in the air due to chemical reaction between two or more components. That is primary pollutant combines with some component of the atmosphere to produce a secondary pollutant (Naik, S., 2005)[17]. Particulate matter formed from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution; the word "smog" is a portmanteau of smoke and fog. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulfur dioxide. Modern smog does not usually come from coal but from

vehicular and industrial emissions that are acted on in the atmosphere by sunlight to form secondary pollutants that also combine with the primary emissions to form photochemical smog. There are many types of air pollutants such as nitrogen oxides, carbon monoxides, and organic compounds that can evaporate and enter the atmosphere. The air pollutants selected in the present study are:

(i) Sulfur dioxide (SO_2)

(ii) Nitrogen dioxide (NO_2)

(iii) Total Suspended Particle (TSP)

(iv) Particle Less Than 10 micron (PM_{10})

(v) Carbon Monoxide (CO)

(vi) Ammonia (NH_3)

(i) Sulfur dioxide (SO_2): It is a colourless gas with a pungent and suffocating odour. The gas is produced by the combustion of fossil fuels (Naik S., 2005)[17]. Sources include industrial activities such as flaring at oil and gas facilities and diesel power generation, commercial and home heating and vehicle emissions. The amount of SO_2 emitted is directly related to the sulfur content of the fuel (Air Quality Monitoring Network, 2008)[3].

(ii) Nitrogen Dioxides (NO_2): The Nitrogen oxide represents the sum of the various nitrogen gases found in the air, of which Nitric Oxide (NO) and Nitrogen Dioxide (NO_2) are the dominant forms. The emission sources are varied but tend to result from high temperature combustion of fuel for industrial activities, commercial and residential heating, and vehicle use. Forest fires can be a large natural source of NO_2 (Air Quality Monitoring Network, 2008)[3].

(iii)Total suspended particulate (TSP): TSP refers to particles ranging in size from the smallest to a generally accepted upper limit of 50-100 microns in diameter. TSP is dominated by the larger sized particles commonly referred to as

"dust" and is associated with aesthetic and environmental impacts such as soiling of materials or smothering of vegetation (Air Quality Monitoring Network, 2008)[3]. The entire domain of particulate matter is known as *Total Suspended Particulate*, TSP (IPCC, 2001). This includes all airborne solid and liquid particles, except pure water, ranging in size from approximately 0.005m*m* to 100m*m* in diameter (Balaceanu C. et al., 2004)[6].

(iv)PM_{10} : Particulate matter is a ubiquitous pollutant, reflecting the fact that it has both natural and anthropogenic sources. Natural sources of primary PM include windblown soil and mineral particles, volcanic dust, sea salt spray, biological material such as pollen, spores and bacteria and debris from forest fires (National Ambient Air Quality Objectives for Particulate matter, 1998)[18]. PM10 refers to particulate matter that is 10 μm or less in diameter.

(v) Carbon Oxide (CO): Carbon monoxide (CO), also called carbonous oxide, is a colorless, odorless, and tasteless gas which is slightly lighter than air. It is highly toxic to humans and animals in higher quantities, although it is also produced in normal animal metabolism in low quantities, and is thought to have some normal biological functions.Carbon monoxide consists of one carbon atom and one oxygen atom, connected by a triple bond which consists of two covalent bonds as well as one dative covalent bond. It is the simplest Oxo carbon. In coordination complexes the carbon monoxide ligand is called carbonyl.

Carbon monoxide is produced from the partial oxidation of carbon-containing compounds; it forms when there is not enough oxygen to produce carbon dioxide (CO_2), such as when operating a stove or an internal combustion engine in an enclosed space.

(vi) Ammonia (NH_3): Ammonia is a compound of nitrogen and hydrogen (and so is covalently bonded) with the formula NH_3. It is a colourless gas with a

characteristic pungent odour. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous. In 2006, worldwide production was estimated at 146.5 million tonnes.(Max Appl (2006)[44]. It is used in commercial cleaning products.

1.3 OBJECTIVES OF THE STUDY

Considering the need of clear air, an air quality study has been performed in the steel city with the following objectives:

(i) To study the weekend /weekday variations of gaseous air pollutants such as SO_2, NO_2, NH_3 and CO at the industrial site (IG-Park) & residential site of Rourkela.

(ii) To study the weekend /weekday variations of particulate air pollutants such as PM_{10} and TSP at the industrial site & residential site of Rourkela.

1.4 EFFECT OF AIR POLLUTION

Air pollution is a basic problem in today's world. Exposure to ambient air pollution has been linked to a number of different health outcomes, starting from modest transient changes in the respiratory tract and impaired pulmonary function, continuing to restricted activity/reduced performance, emergency room visits and hospital admissions and to mortality. There is also increasing evidence for adverse effects of air pollution not only on the respiratory system, but also on the cardiovascular system (WHO, 2004). Physical damage functions relating health (mortality and morbidity) to air pollution levels have been estimated over a number of years in different countries) (Powe Neil A., et al, 2002)[19]. Although the net effect of pollutants on health is unclear, the Committee of the Medical Effects of

Air Pollution (COMEAP), set up by the UK government has found the strongest link between health and pollution to be for particulates (PM_{10}), sulfur dioxide (SO_2) and ozone (O_3) (Powe Neil A., et al, 2002)[19].

The major air pollutants discussed in the present study are sulfur dioxide, nitrogen oxides, ammonia, carbon monoxide, TSP and PM_{10}.The harmful effects of these pollutants are discussed here in detail:

(i) Sulfur Dioxide (SO_2): Elevated concentrations of SO_2 can be indicated by an odor of 'burning matches' and are associated with human health impacts, including respiratory (breathing) effects, especially asthma. Vegetation, especially lichens, can be very sensitive to SO_2 at relatively low concentrations (Air Quality Monitoring Network, 2008)[3]. The gas irritates airways and eyes and is known to cause longer-term heart diseases, other cardiovascular ailments, and bronchitis. It also readily causes shortness of breath and coughing amongst asthma sufferers. SO_2 is also a major contributor to acid rain, which damages the environment and upsets ecosystems (Chan Wai-Shin et al, 2007)[8]

(ii) Nitrogen Dioxides (NO_2): It causes severe respiratory problems, especially in children. When combined with water, it forms nitric acid and other toxic nitrates. NO_2 is also a main component in the formation of ozone at the surface level. The gas irritates the lungs and has been known to lower the immune system (Chan Wai-Shin et al, 2007)[8]. It may cause acidification and eutrophication harmful to health (mainly the respiratory system), materials, cultural artifacts, vegetation and crops (Sida, unknown). Elevated concentrations of NO_2 can also affect visibility though creation of'reddish brown' hazes (Air Quality Monitoring Network, 2008) [3].

(iii) Total suspended particulate (TSP): TSP is associated with aesthetic and environmental impacts such as soiling of materials or smothering of vegetation (Air Quality Monitoring Network, 2008)[3].It may pose the greatest threat to

human health because, for the same mass, they absorb more toxic and carcinogenic compounds than larger particles and penetrate more easily deep into the lungs (Masitah Alias et al, 2007)[4].

(iv) PM_{10} : The increases in particulate matter have been shown to cause small, reversible decrements in lung function in normal asymptomatic children, and in both adults and children who have some form of pre-existing respiratory condition, particularly asthma. These changes were often accompanied, especially in adults, by increases in symptoms such as chronic bronchitis or cough (National Ambient Air Quality Objectives For Particulate matter, 1998)[18].

(V) Carbon Monoxide (CO): Carbon monoxide is a toxic gas, but, being colorless, odorless, tasteless, and initially non-irritating, it is very difficult for people to detect. Carbon monoxide is a product of incomplete combustion of organic matter due to insufficient oxygen supply to enable complete oxidation to carbon dioxide (CO_2). Symptoms of mild acute poisoning include lightheadedness, confusion, headaches, vertigo, and flu-like effects; larger exposures can lead to significant toxicity of the central nervous system and heart, and even death. Following acute poisoning, long-term sequelae often occur. Carbon monoxide can also have severe effects on the fetus of a pregnant woman. Chronic exposure to low levels of carbon monoxide can lead to depression, confusion, and memory loss. Carbon monoxide mainly causes adverse effects in humans by combining with hemoglobin to form carboxyhemoglobin (HbCO) in the blood. This prevents oxygen binding to hemoglobin, reducing the oxygen-carrying capacity of the blood, leading to hypoxia.(Prockop LD, Chichkova RI (Nov 2007)[48]. "Carbon monoxide intoxication: an updated review". *Journal of the Neurological Sciences* 262 (1-2), Buckley NA, Isbister GK, Stokes B, Juurlink DN (2005).[47] "Hyperbaric oxygen for carbon monoxide poisoning: a systematic review and critical analysis of the evidence". *Toxicological Reviews* 24 (2): 75–92)

(vi) Ammonia (NH_3): The human body has several ways to process the ammonia it produces and is capable of clearing large levels of ammonia from its system. Ammonia levels in the air as low as 5 parts per million (ppm) can be recognized by odor. An average person detects ammonia by odor at around 17 ppm. According to the World Health Organization (WHO), continuous exposure to 25 ppm of ammonia in the air does not result in a significant increase in blood levels of ammonia in the body. According to the Occupational Safety and Health Administration (OSHA), the least amount of ammonia which is found to be irritating to the eyes, nose and throat of the most sensitive individuals is 50 ppm. There is no evidence that ammonia causes cancer. There is no evidence that exposure to the levels of ammonia found in the environment causes birth defects or other developmental effects. Because ammonia is present in the human body at all times, no long-term health effects from inhalation exposure to low levels of ammonia would be expected. Because ammonia is a respiratory tract irritant, persons who are hyper reactive to other respiratory irritants, or who are asthmatic, may be expected to be more susceptible to inhalation of high concentrations of ammonia. (The Fertilizer Institute, Nourish, Replenish, Grow)[45]

CHAPTER 2

LITERATURE REVIEW

The rapid industrialization leading to urbanization, unplanned and excessive exploitation of natural resources have been causing pollution problems in cities and towns of developing countries. Man made and natural sources of emissions have polluted the air with toxic substances. The national average per capita SO_2 emission was 4.2 kg per person in 1990, which rose to 5 kg in 1995, an increase of almost 20% in 5 yr. In 1990, coal consumption contributed 64% of total SO_2 emissions in India, oil products 29%, biomass 4.5% and non-energy consumption 2.5% (Garg, A., et.al, 2001)[10]. Total SO_2 and NO_x emissions from India were 3542 and 2636 Gg respectively (1990) and 4638 and 3462 Gg (1995) growing at annual rate of around 5.5%. The sectoral composition of SO2 emissions indicates a predominance of electric power generation sector (46%). Power and transport sector emissions equally dominate NO_X emissions contributing nearly 30% each (Garg, A., et.al, 2001)[10]. The ambient air quality in Madurai City of South India was studied and it was found that the TPM concentration varied from 200 to 500 μg / cu-m, NO_x from 50 to 170 μg / cu-m and SO_2 from 10 to 25 μg / cu-m. The Ambient Air Quality of Jyotivihar, Orissa in terms of TSP, SO_2 and NO_x was studied during December–1994 to November–1995. The minimum and maximum values were 82.995 μg/cu-m and 182.7 μg/cu-m for TSP, 4.62 μg/cu-m and 25.74 μg/cu-m for SO2 and 4.39 μg/cu-m and 16.89 μg/cu-m for NO_x (Naik S., 2005)[17]. A report showed that SPM concentrations in Shanghai, New Delhi, Mumbai, Guangzhou, Chongquin, Calcutta, Beijing and Bangkok exceeded WHO limits (90 μg/cu-m) by three, five, three, three, four, four, four and two times respectively . It also showed that PM_{10} exceeded the USEPA limit (50μg/cu-m) by several times in a number of cities, most notably by over four times in New Delhi and Calcutta. Data from Tokyo shows that TSP increased rapidly from 40μg/cu-m in the early 1980s to over 70μg/cu-m in the early 1990s; after that TSP has been decreasing or stagnating, but it is becoming an increasing challenge to contain TSP

and NO_x (Air Pollution Control in the Transportation Sector, 2007)[2]. The Central Pollution Control Board monitors the quality of air at nine stations in Delhi. The latest data published before the field work commenced pertained to 1991(CPCB, 1992). The range of mean annual concentrations across these nine stations were: total suspended particulates (TSP) =255–643 μg/cu-m; nitrogen dioxide (NO_2) =24.2–61.7 μg/cu-m; sulfur dioxide (SO_2) =8.4–51.2 μg/cu-m. The overall mean level of RSP in this micro-environment was 390μg/cu-m. The average level of PM_{10} as measured at nighttime indoors was found to be comparably very high F 900 μg/cu-m (Saksena et al, 2003)[23].

A recent study in middle-income homes of Delhi found PM_{10} levels to be as high as 170–810 μg/cu-m even in homes where there was no cooking or smoking activity (Kumar, 2001)[23]. A study for assessment and management of air quality was carried out in the Ib Valley area of the Ib Valley coalfield in Orissa state, India. The 24 h average concentrations of total suspended particulate (TSP), respirable particulate matter (PM_{10}), sulfur dioxide ($SO_{2)}$ and oxides of nitrogen ($NO_{x)}$ were determined at regular intervals throughout one year at twelve monitoring stations in residential areas and six monitoring stations in mining/industrial areas. The 24 h average TSP and PM_{10} concentrations were124.6-390.3 μg/cu-m and 25.9–119.9 μg/cu-m in residential areas, and were 146.3–845.2 μg/cu-m and 45.5–290.5 μg/cu-m in industrial areas.

The rural-industrial site at Satna shows significant different from urban, urban-industrial, rural, rural-remote and rural–urban influenced sites. With a minimum of one daily sample at each site, mean PM_{10} concentration at the rural-industrial Satna site varied from 65.5 to147.5 μg/cu-m, and from 205.0 to 320.3μg/cu-m at the urban-industrial Delhi site. With a minimum of one daily sample at each site, the mean TSP concentration at the rural-industrial Satna site varies from 283.9 to 678.0 μg/cu-m, while at the urban industrial Delhi site mean TSP concentration

varies from 553.4 to 827.6 μg/cu-m. The maximum TSP concentration in Satna, 678.0 μg/cu-m, was on December 9, 2000. Maximum TSP concentration in Delhi, 827.6 μg/cu-m, occurred on October 23, 2000. Levels of TSP in Ashok Vihar, a residential area in Delhi, reached 10 times the permissible limit in October 2000 (Shandilya Kaushik. K. et al, 2007)[24].

The atmospheric concentrations of gaseous ammonia has been measured by Perrino et al. (2002)[40] during spring of 2001 to spring of 2002 in an urban area of Rome, at many traffic sites and at an urban background sites. The results indicated that emissions from petrol–engine vehicles equipped with catalytic converters could be an important source of ammonia in urban areas. Whereas, in another study in south coast air basin, mobile sources were estimated to represent 18% of the NH_3 inventory (Chitjian et al., 2000)[41].

Burkhardt et al.(1998)[42] measured atmospheric ammonia (NH_3) concentrations over a period of two years near Edinburgh, Scotland and concluded that arithmetic mean of NH_3 concentrations was largest in spring and autumn. This study also confirmed that NH_3 concentrations were influenced by local sources and background concentrations depending on the wind direction.

CHAPTER 3

SITE DESCRIPTION

3.1 STUDY AREA

A steel city, Rourkela, is selected as a study area in the present research work. It is one of the most important industrial cities in the Sundargarh district of the State of Orissa in India. It has a population of more than four hundred thousand people, many of them Adivasis belonging to different indigenous communities.

Table 1: A Brief Profile of Rourkela, Orissa

A Brief Profile of Rourkela	
Annual Rainfall	128.8 cm. Average
Temperature	46.3°C (Max.) in Summer 07° C (Min.) in Winter
Latitude	22°-12° North of the Equator
Longitude	84°-54° East of Meridian
Altitude	219 Mts above Sea Level
Area	200 Sq. Km. Approx..
Density of Population	2,500 per Sq. Km. Approx.
Sex Ratio	835 Female per 1000 male (as per the censes of 1991)
Literacy	86.5% (1996)
Per Capita income	Highest in Orissa
Population (1991)	3,98,864 SC 35,687 ST 66,627
Population (2001)	4,84,292 (Township: 206,566, Rourkela:224,601)
Total Carbon Emissions (RSP)	16.54 MTPA
Increased Emission from Expansion Rourkela Steel Plant (TSP)	9.48 MTPA

SOURCE :(Orissa State Water Plan, 2004, The total amount of shareholder capital that has been paid in full by shareholders, Singhal K.K, ED, SAIL, Energy Efficiency in Steel Industry and Clean Development Mechanism (CDM), International Convention on Clean, Green & Sustainable Technologies in Iron & Steel Making, Bhubaneswar)[34,35,36].

The population density in the industrial complex is 3,288 persons per square kilometer. The Industrial complex is situated approximately 215-230 m above the mean sea level (msl). The city is spread over an area of 121.7-km^2 in close proximity of iron ore, dolomite, limestone and coal belts.

The region is surrounded by the Durgapur hill range. The perennial Koel River flows through this valley and meets another perennial river Sankh at Vedavyas on the outskirts of Rourkela. Beyond this, the river is known as Brahmani. Brahmini is one of the 14 major river systems in the country and is considered among the most polluted in parts (Orissa State Water Plan, 2004)[34]. Brahmini, Koel and Sankh rivers form the major drainage in the area.

CHAPTER 4

Monitoring Protocol

4. 1 Monitoring Protocol

To Study the weekend / weekday variations of major air quality parameters, An air sampling network has been performed, during January 2011 to April 2011 to collect ambient SO_2, NO_2, CO, NH_3, PM_{10} & TSP concentrations.

The main concern of the project is to measure the concentration of sulfur dioxide, nitrogen dioxide, ammonia, carbon monoxide, PM_{10} and total suspended particles taking readings at different stations with the help of respirable dust sampler. These critical gaseous pollutants and the particulate pollutants are in abundance in Rourkela environment since it is an industrial area and a little change in their concentration in ambient air can make a strong effect on the existing living stock causing many adverse effects on health and skin. As we are primarily concerned about the environment of the Rourkela, so we decided to choose the sampling stations in the densely populated area. The stations were so chosen that there can be adequate safety measures experiment. We investigated the decided sampling stations and found out the possible problems and the possible precautions to be taken while handling and use of the device for the project.

The monitoring stations chosen are:

1. Station-1: In front of IG park 2. Station-2: At Udit Nagar

4.2 PROBLEMS FACED DURING OPERATIONS

The implementation of the sampling devices at the aforesaid stations was quite difficult to deal with. The following problems were faced during our operation:

Station I: In station-1,that is In front of IG park ,everything seemed to be fine about the setting up of the device and connection for electricity except we had to be aware of the students who found it curious enough to touch and handle it.

Station II: At Udit Nagar, It has been found the same difficulties as in the station-1.along with that there was also another problem that was to be taken care of , like many people were coming near the apparatus .

Site Map

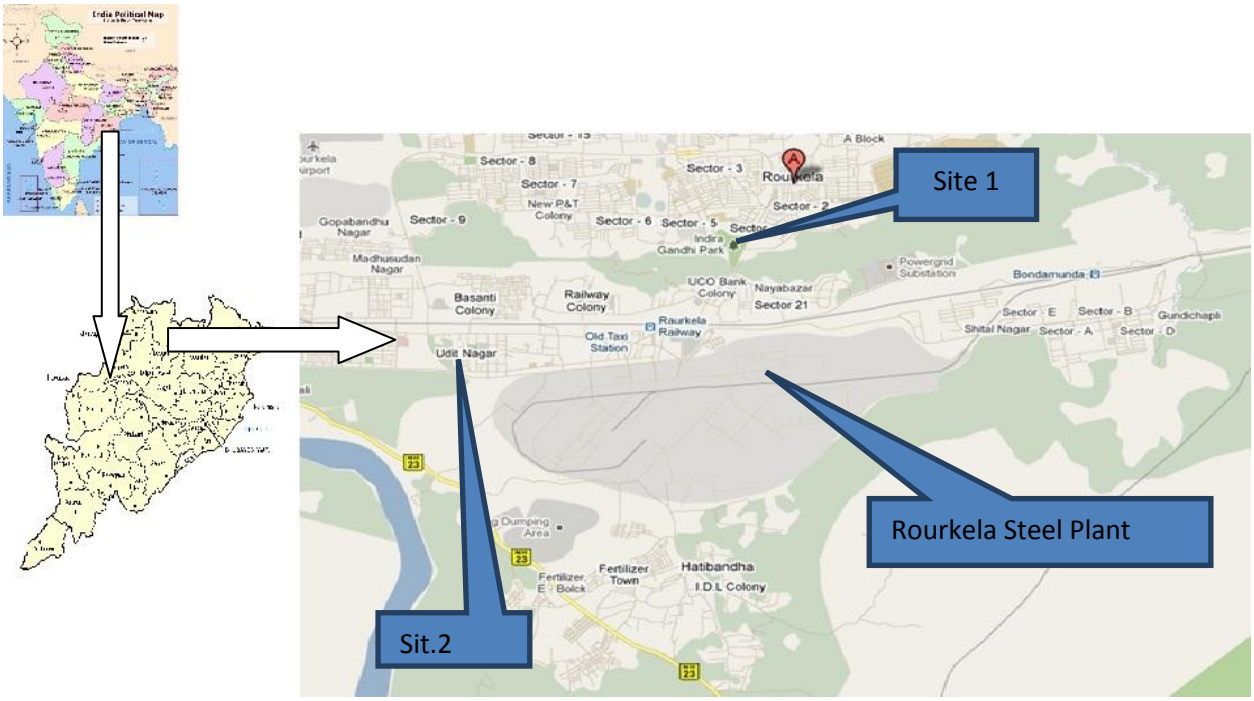

FIGURE1: MAP OF STUDY AREA

4.3 SAMPLING AND TECHNIQUES

4.3.1 Sampling and Analysis Techniques of Nitrogen Dioxide

Assemble in order as shown in, a sampling probe (optional), fritted-tip absorber, mist eliminator or trap, flow meter, and pump. Measure temperature and pressure difference from atmospheric so that corrections for gas volume may be applied. Keep the flow meter free from spray or dust. Use ground-glass connections. Butt-

to-butt glass connections with vinyl tubing also may be used for connections without losses if lengths are kept minimal. Pipet 10.0 ml of absorbing reagent into a dry fritted bubbler. Draw an air sample through it at the rate of 0.4 L/min, long enough to develop sufficient final color (about 10 to 60min). Note the total air volume sampled. Measure and record air temperature and pressure. After using the bubbler, rinse well with water and dry. If fritted tip is visibly discolored, clean in accordance with the procedure. After sampling, development of the red-violet color is complete within 15 min at room temperatures. Transfer to a stoppered cuvette and read in a spectrophotometer at 550 nm, using distilled water as a reference. Deduct the absorbance of the reagent blank from that of the sample. Colors too dark to read may be quantitatively diluted with unexposed absorbing reagent. Then multiply the measured absorbance by the dilution factor.

4.3.2 Sampling and Analysis Techniques of Sulfur Dioxide

Place 10 mL of TCM absorbing reagent in a midget impinger and seal the impinger with a thin film of silicon stopcock grease (around the ground glass joint). Insert the sealed impinges into the sampling train as shown, making sure that all connections between the various components are leak tight. Greaseless ball joint fittings, heat shrinkable TFE-fluorocarbon tubing, or TFE-fluorocarbon tube fittings may be used to attain leak free conditions for portions of the sampling train that come into contact with air containing SO_2. Shield the absorbing reagent from direct sunlight by covering the impinger with aluminum foil or by enclosing the sampling train in a light-proof box. Determine the flow rate. Collect the sample at 1±0.10 L/min for 30 min sampling or 0.500 ± 0.05 L/min for 1 h sampling. Record the exact sampling time in min, as the sample volume will later be determined using the sampling flow rate and the sampling time. Record the atmospheric pressure and temperature.

4.3.3 Sampling and Analysis Techniques of PM_{10}

Air is drawn through a size-selective inlet and through a 20.3 cm x 25.4 cm filter (quartz microfiber).Particles with aerodynamic diameter less than the cut-point of the inlet are collected by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM_{10} in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

4.3.4 Sampling and Analysis Techniques of Carbon Monoxide

Carbon monoxide: The level of carbon monoxide present in the air is found with the help of an instrument called HT-1000 H CARBON MONONXIDE METER. The instrument has a digital display and detects the presence of carbon monoxide, measuring concentration between 1-1000 ppm. It can record 10 sets of data & pocket size in nature, makes it easy to use. The sampling time is 8 hours and reading is taken in every half an hour, to check the amount of carbon monoxide present in the air.

4.3.5 Sampling and Analysis Techniques of Ammonia

Ammonia (NH_3): The solution is taken from the impinger, it consist of NH_4Cl. The absorbing agent used for ammonia was 0.2N boric acid. Boric acid will react with ammonia to form ammonium borate. Then add Nesseler's reagent (2-3 drops), till we get a yellow color solution. Now the solution is analyzed with UV-spectrometer. The wavelength used for the analysis of NH_3 is 425×10^{-9} and rest the same procedure will be followed, as done for SO_2.

4.3.6 Sampling and Analysis Techniques of Total Suspended Particles

Total suspended particles (TSP): Since only a small portion of the total air sample passes through the flow-meter during measurement, the flow-meter must be calibrated against actual air flow with the orifice calibration unit. Before the orifice

calibration unit can be used to calibrate the flow meter, the orifice calibration unit itself must be calibrated against the positive displacement primary standard.

Attach the orifice calibration unit to the intake end of the positive displacement primary standard and attach a high volume blower unit to the exhaust end of the primary standard. Connect one end of a differential manometer to the differential pressure tap of the orifice calibration unit and leave the other end open to the atmosphere. Operate the high volume motor-blower unit so that a series of different, but constant airflows, usually six, are obtained for definite time periods. Record the reading of the different constant airflows, which are obtained by placing series of loads, one at a time, between the calibration unit and the primary standard. Place the orifice, before the inlet reduces the pressure, at the inlet of the primary standard below atmosphere. A correction must be made, therefore, for the increase in volume caused by this decreased inlet pressure. Attach one end of a second differential manometer- to the inlet pressure tap of the primary standard and leave the other end of the manometer open to the atmosphere. During each of the constant airflow measurements made above, measure the true inlet pressure of the primary standard with this second differential manometer. Measure the atmospheric pressure and temperature. IS 5182(part4): 1999)

4.3.7 Monitoring Instrument

Air is drawn into a covered housing and through a filter by a high flow rate blower at 1.1 to 1.5 cu-m/min that allows suspended particulate matter with diameters <10μm (Stokes equivalent diameter) to collect on the filter surface. Particles with diameters of 0.1 to 10 μm are collected on glass fiber filters.

The mass concentration of PM_{10} μg/cu-m in ambient air is computed by measuring the mass of PM_{10} collected and the volume of air sampled. The size of the sample collected is usually adequate for further analysis of trace elements.

The sample of air is first drawn into a cyclone separator, which passes only the smaller particles with diameter less than 10 μm. These are then collected on the filter, as before, while the larger "non-respirable" particulates are collected in a removable dust collector cup. PM10 is calculated by measuring the mass collected on the filter and the volume of air sampled, while NRPM is calculated by measuring the mass collected on the dust collector cup and the volume of air sampled.

Sampling at an average of 1.1cu-m/min for 24 hours, given an adequate sample, even in an atmosphere having concentrations of particulates as low as 1μg/cum. If particulates levels are unusually high, a satisfactory sample may be obtained in 6 to 8 hours or less. For determination of average concentrations of suspended particulates in ambient air, a standard sampling period of 24 hours is recommended. Weights are determined to the nearest milligram, air flow rate are determined to the nearest 0.05 cu-m/min, times are determined to the nearest 1 minute, and mass concentrations are reported to the nearest microgram per cubic meter (μg/cu-m).

Particulate matter that is oily, such as photochemical smog or wood smoke, may block the filter and cause a rapid drop in airflow at a non uniform rate. Dense fog or high humidity can cause the filter to become too wet and severely reduce the air flow through the filter. Glass-fiber filters are comparatively insensitive to changes in relative humidity, but collected particulates can be hygroscopic.

Nettle's Respirable dust sampler, model NPM-HVS/R consist main part- the control module. The control module houses all the functional parts required for the collection of particulates and gaseous samples. The gaseous sampling arrangements detailed specifications are given below:

Heavy duty blower: 1.5 cu-m/min free flow (without resistance)

Blower duty cycle: Continuous/ 24 hour's maximum with proper maintenance of carbon brush.

Voltage stabilizer: For rallies blower motor

Input: 145-275 V AC (standard)

Output: 230+/- 10 V AC

Auto shut off timer: 0-24 hours

Timer totaliser: 0-9999 min.

Flow controller: Solid state continuously variable.

Flow measurement: U tube manometer with pitot tube and calibration curve.

Filter holder assembly: Fiber with EPDM gasket.

Filter paper: 25 cm × 20 cm (overall)

Dimensions: 23 cm × 18 cm (effective)

Options: Brushless motor, specification 0.5 HP, 3000 RPM, AC single phase motor 1.6 cu-m/min.

Particulate sampling (TSP): From 100 microns to 0.1 microns depending upon the type of filter paper used. Particulates above 10 microns are collected separately in the cup.

Gaseous Sampling:

Glass impinger tubes: 4 nos. 35ml capacity

Rotameter: 0-3 lpm, acrylic body.

Dimensions of control module: 85 (H) × 46.5 (W) × 30 (D) cm.

The Respirable dust sampler consist of control module (Figure-5.1) designed to maintain height of air inlet to 1.5 m. This unit separates particulate matter by size, passing the small respirable particulate to the filter and retaining the large non-respirable particulate matter in a cup. The major parts are described below:

Main housing: The main housing is made of powder coated metal, to withstand corrosive and humid atmospheres. It has one door which gives access to all parts.

Filter holder: The filter holder assembly consist hopper assembly made up of FRP to hold 25 cm × 20 cm filter paper. EPDM gasket helps to make the assembly tight. The effective size of the filter paper for suction is 23 cm × 18 cm knobs are provided for easy replacement of filter paper.

Blower assembly: A heavy duty blower with continuous rating 24 hrs. Max with proper carbon brush maintenance and operating on 230 V AC. 50 Hz is fitted with the hopper assembly. The carbon brushes of the blower can be easily replaced by unscrewing them.

Brushless motor: 0.5 HP, 3000 RPM, AC single phase motor 1.6 cu-m/min.

U-tube manometer: The flow rate is monitored by means of U- tube manometer and a pilot tube at the blower exhaust. A factory calibration curve of flow rate, in units of LPM of 250C air, verses manometer ΔP at 300C. In units of water cm, is fixed on the sampler. The horizontal axis of the graph is linear ΔP.

Voltage stabilizer: An automatic voltage stabilizer is provided to keep the voltage output at 230 + 10 V.

Auto shut off timer: The sampler has a on-off timer where sampling time can be set from 0 to 24 hours with auto shut off facility.

Time totaliser: A time totaliser has been provided to indicate the total time of sampling in minutes. It has a maximum range of 9999 minutes. Total time of sampling is calculated by difference of final and initial time in minutes.

Flow controller: To set and adjust the blower flow rate at the time of sampling, a continuously variable type flow is provided.

Impinger tubes with restrictors: For gaseous sampling 4 nos. of graduated impninger tubes. (Midget impingers) having capacity of 35 ml each are supplied. The flow of sampling air through each impinge tubes can be controlled by individual, connected to the manifold.

Inlet & separator unit: Ambient air is drawn into the sampler through a cyclone separator to create a cyclonic flow, Large dust particles impact on the inner wall of the tube and drop down to be collected in the cup. Small dust particles filter with less than 10 microns (Stokes) diameter are assessed along with the air drawn through the filter and collected on it.

Figure2: Respirable dust sampler

Figure3: Gaseous attachment of dust sampler

CHAPTER 5

RESULTS & DISCUSSION

5.1 Results

In the present study , weekend /weekday variations of selected gaseous and particulate matters are shown in figure 4 to figure 20 .

5. 1.1 Ammonia (NH_3)

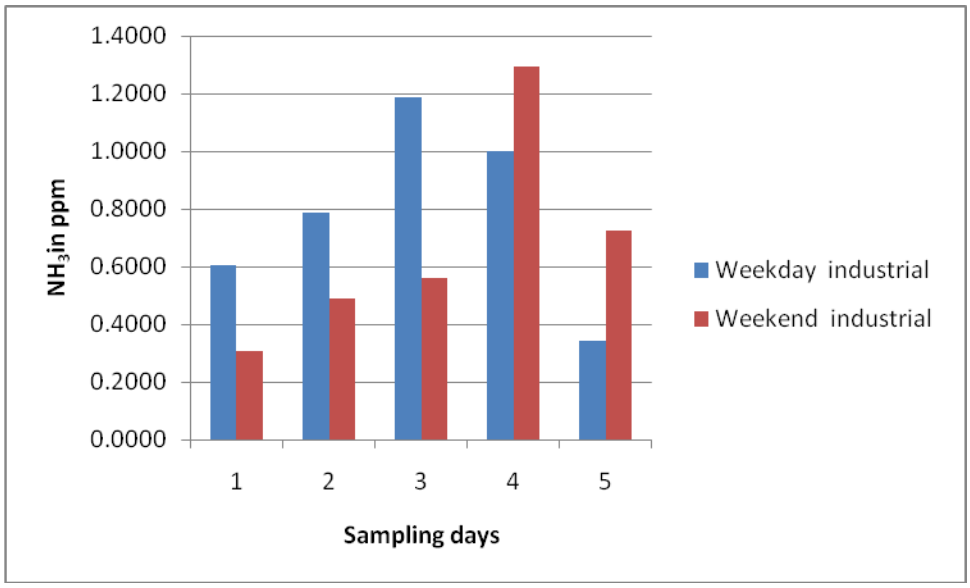

Figure4: Concentration of Ammonia in Air (Weekend / Weekday) at Industrial site

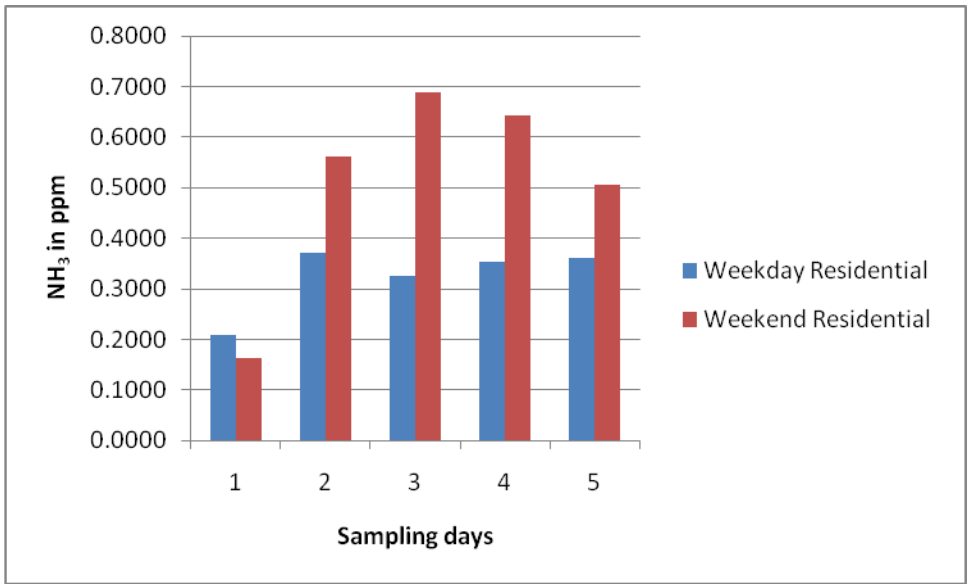

Figure 5: Concentration of Ammonia in Air (Weekend / Weekday) at Residential site

Table 2 : Concentration of Ammonia in Air at Different Monitoring Sites

Sampling Site	Sampling Days	Conc of NH_3 (ppm)
Industrial	20/01/2011	0.6060
Industrial	23/01/2011	0.3075
Industrial	30/01/2011	0.4884
Industrial	20/02/2011	0.5608
Industrial	23/02/2011	0.7860
Industrial	27/02/2011	1.2918
Industrial	04/03/2011	1.1867
Industrial	18/03/2011	1.0010
Industrial	19/03/2011	0.7236
Industrial	23/03/2011	0.3437
Residential	26/03/2011	0.1628
Residential	31/03/2011	0.2080
Residential	05/04/2011	0.3708
Residential	09/04/2011	0.5608
Residential	16/04/2011	0.6874
Residential	18/04/2011	0.3256
Residential	21/04/2011	0.3527
Residential	23/04/2011	0.6422
Residential	28/04/2011	0.3618
Residential	30/04/2011	0.5065

5.1.2 Nitrogen Dioxide:

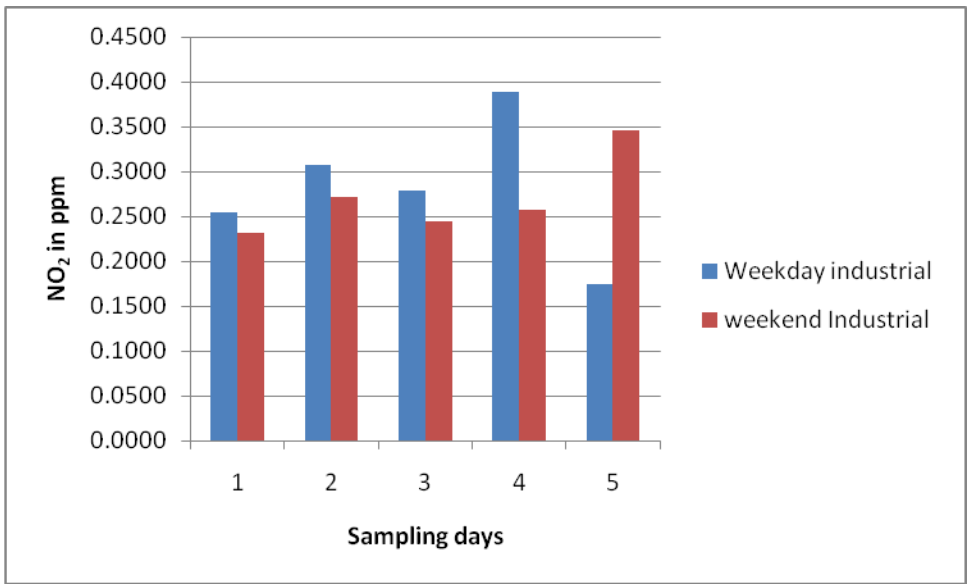

Figure6 : Concentration of Nitrogen Dioxide in Air (Weekend /Weekday) at Industrial site

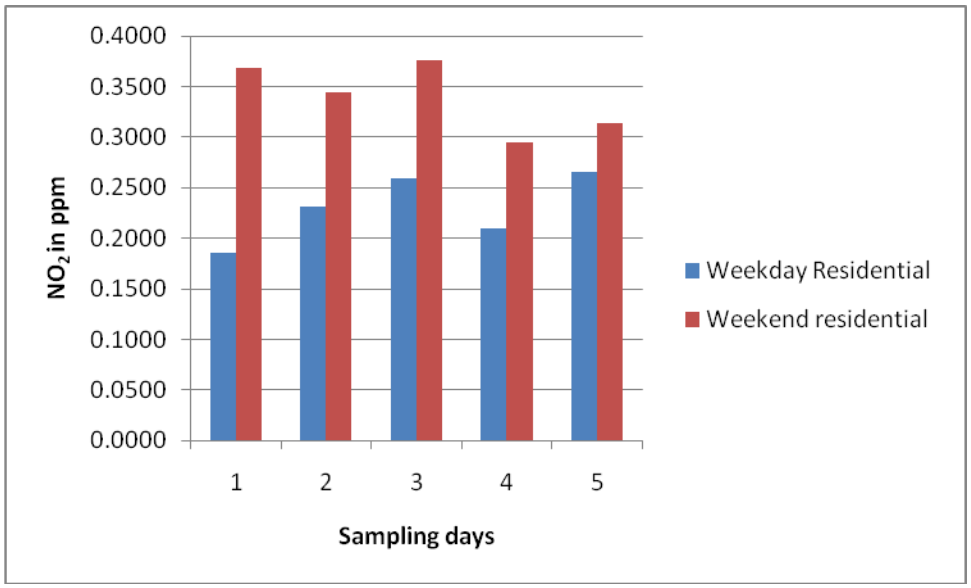

Figure 7 : Concentration of Nitrogen Dioxide in Air (Weekend /Weekday) at Residential site

Table 3: Concentration of Nitrogen Dioxide in Air at Different Monitoring Sites

Sampling Site	Sampling Days	Conc of NO_2 (ppm)
Industrial	20/01/2011	0.2547
Industrial	23/01/2011	0.2319
Industrial	30/01/2011	0.2716
Industrial	20/02/2011	0.2439
Industrial	23/02/2011	0.3076
Industrial	27/02/2011	0.2571
Industrial	04/03/2011	0.2788
Industrial	18/03/2011	0.3881
Industrial	19/03/2011	0.3461
Industrial	23/03/2011	0.1742
Residential	26/03/2011	0.3689
Residential	31/03/2011	0.1851
Residential	05/04/2011	0.2319
Residential	09/04/2011	0.3449
Residential	16/04/2011	0.3761
Residential	18/04/2011	0.2596
Residential	21/04/2011	0.2091
Residential	23/04/2011	0.2944
Residential	28/04/2011	0.2656
Residential	30/04/2011	0.3136

5.1.3 Sulfur Dioxide (SO_2) :

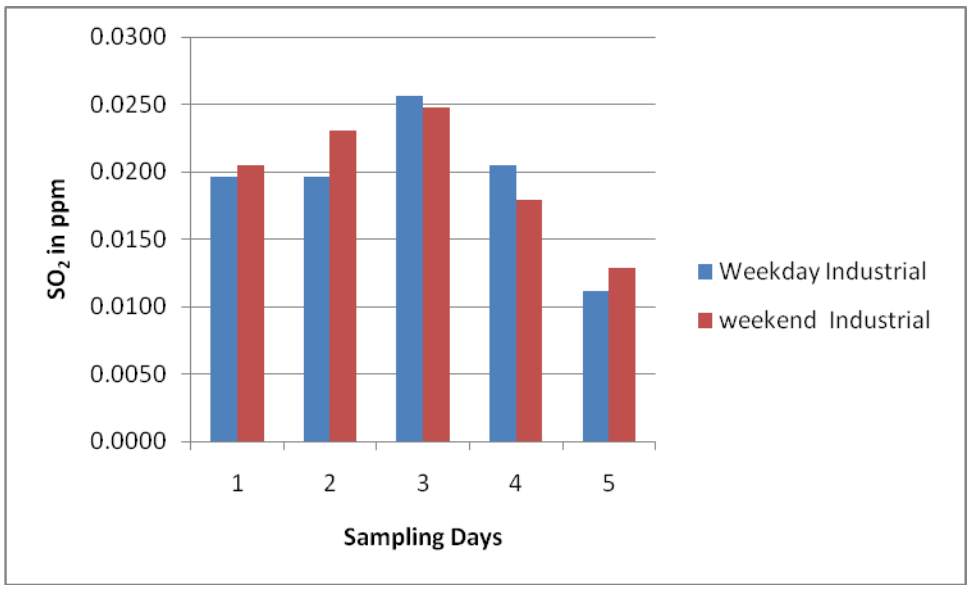

Figure 8: Concentration of Sulfur Dioxide in Air (Weekend / Weekday) at Industrial site

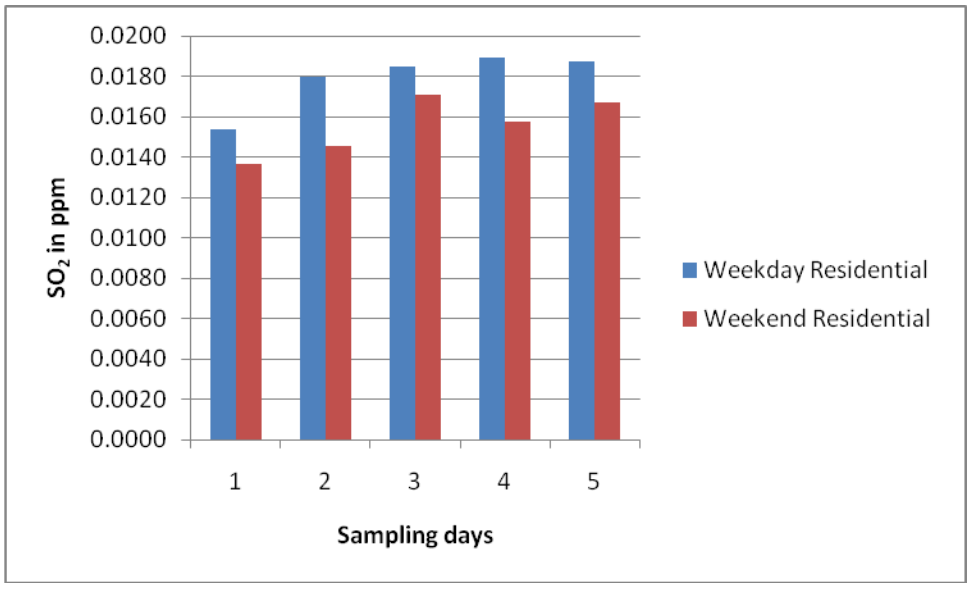

Figure 9: Concentration of Sulfur Dioxide in Air (Weekend / Weekday) at Residential site

Table 4: Concentration of Sulfur Dioxide in Air at Different Monitoring Sites

Sampling Site	Sampling Days	Conc of SO_2 (ppm)
Industrial	20/01/2011	0.0197
Industrial	23/01/2011	0.0205
Industrial	30/01/2011	0.0231
Industrial	20/02/2011	0.0248
Industrial	23/02/2011	0.0197
Industrial	27/02/2011	0.0180
Industrial	04/03/2011	0.0257
Industrial	18/03/2011	0.0205
Industrial	19/03/2011	0.0128
Industrial	23/03/2011	0.0111
Residential	26/03/2011	0.0137
Residential	31/03/2011	0.0154
Residential	05/04/2011	0.0180
Residential	09/04/2011	0.0145
Residential	16/04/2011	0.0171
Residential	18/04/2011	0.0185
Residential	21/04/2011	0.0189
Residential	23/04/2011	0.0157
Residential	28/04/2011	0.0187
Residential	30/04/2011	0.0167

5.1.4 Carbon Monoxide (CO) :

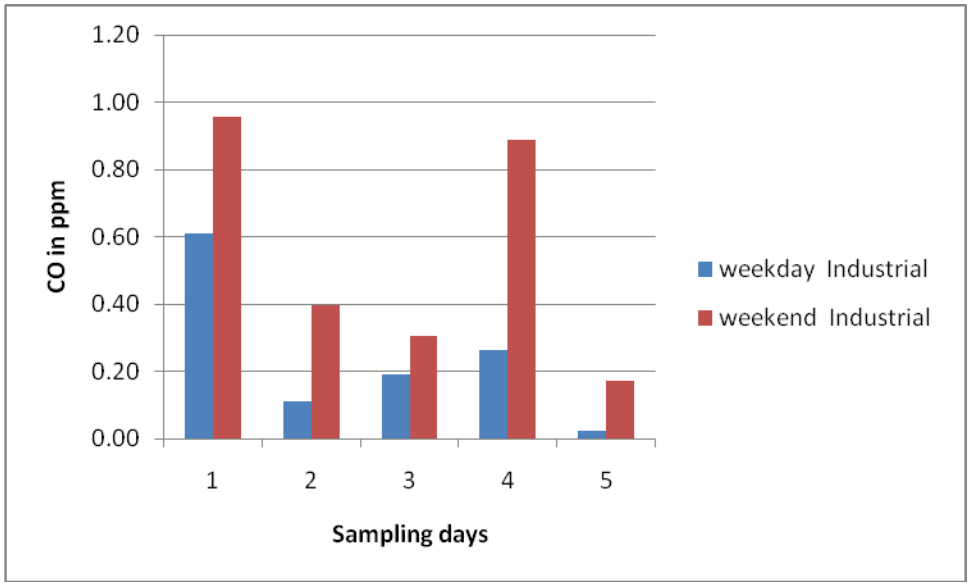

Figure10: Concentration of Carbon Monoxide Air (Weekend / Weekday) at Industrial site

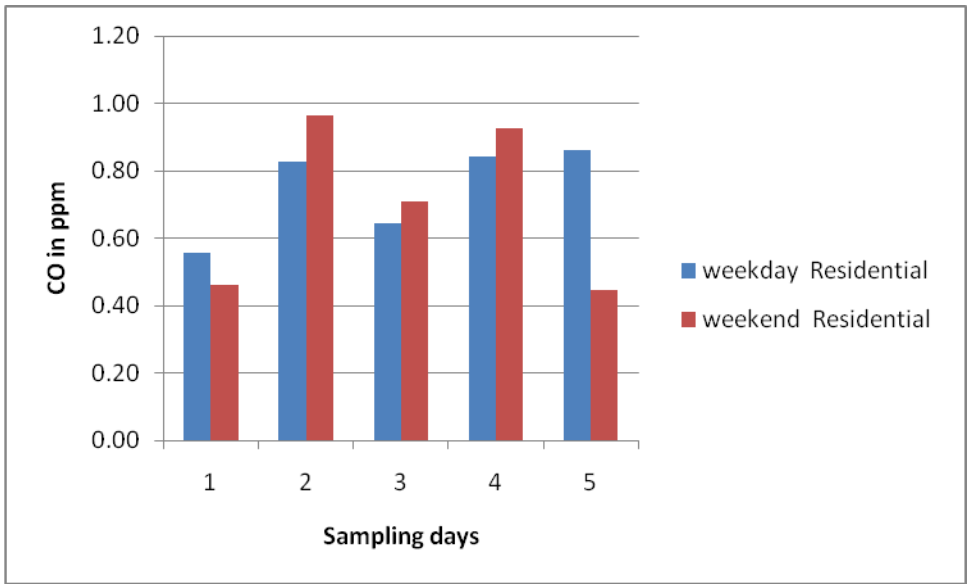

Figure 11: Concentration of Carbon Monoxide Air (Weekend / Weekday) at Residential site

Table 5: Concentration of Carbon Monoxide in Air at Different Monitoring Sites

Sampling Site	Sampling Days	CO in ppm
Industrial	20/01/2011	0.61
Industrial	23/01/2011	0.96
Industrial	30/01/2011	0.40
Industrial	20/02/2011	0.31
Industrial	23/02/2011	0.11
Industrial	27/02/2011	0.89
Industrial	04/03/2011	0.19
Industrial	18/03/2011	0.26
Industrial	19/03/2011	0.17
Industrial	23/03/2011	0.02
Residential	26/03/2011	0.46
Residential	31/03/2011	0.56
Residential	05/04/2011	0.83
Residential	09/04/2011	0.96
Residential	16/04/2011	0.71
Residential	18/04/2011	0.64
Residential	21/04/2011	0.84
Residential	23/04/2011	0.93
Residential	28/04/2011	0.86
Residential	30/04/2011	0.44

5.1.5 Total Suspended Particle (TSP) and PM_{10}:

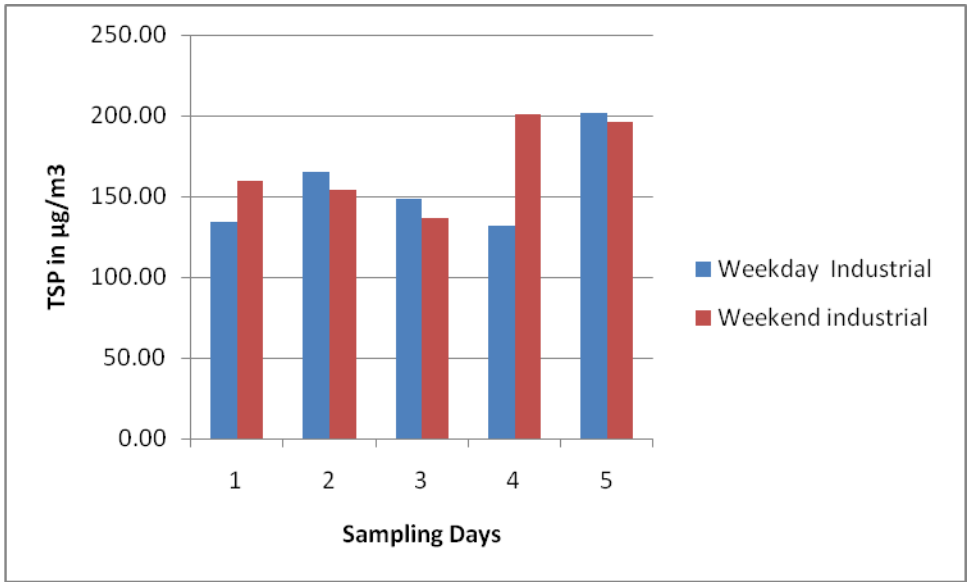

Figure 12: Concentration of Total Suspended Particle (TSP) In Air (Weekend / Weekday) at Industrial site

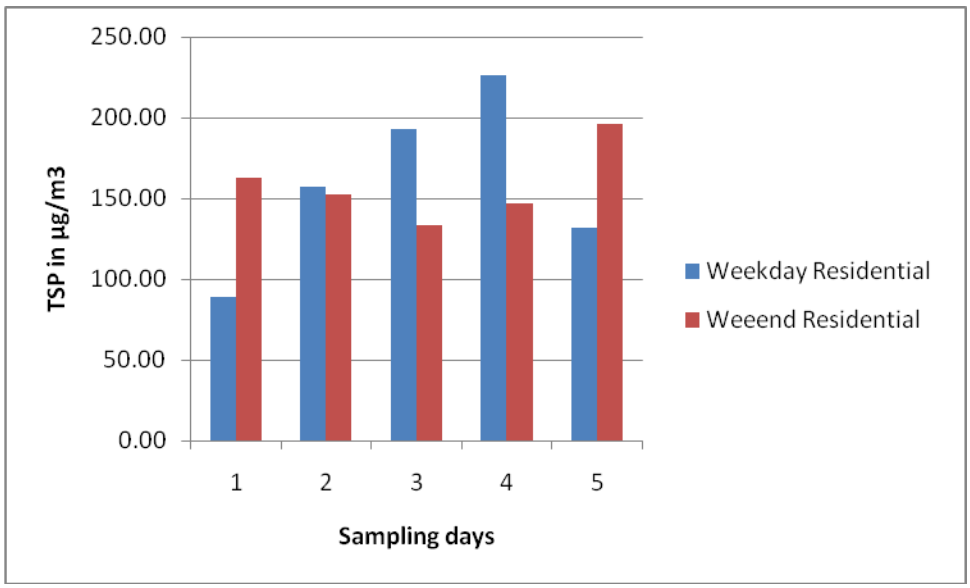

Figure13: Concentration of Total Suspended Particle (TSP) In Air (Weekend / Weekday) at Residential site

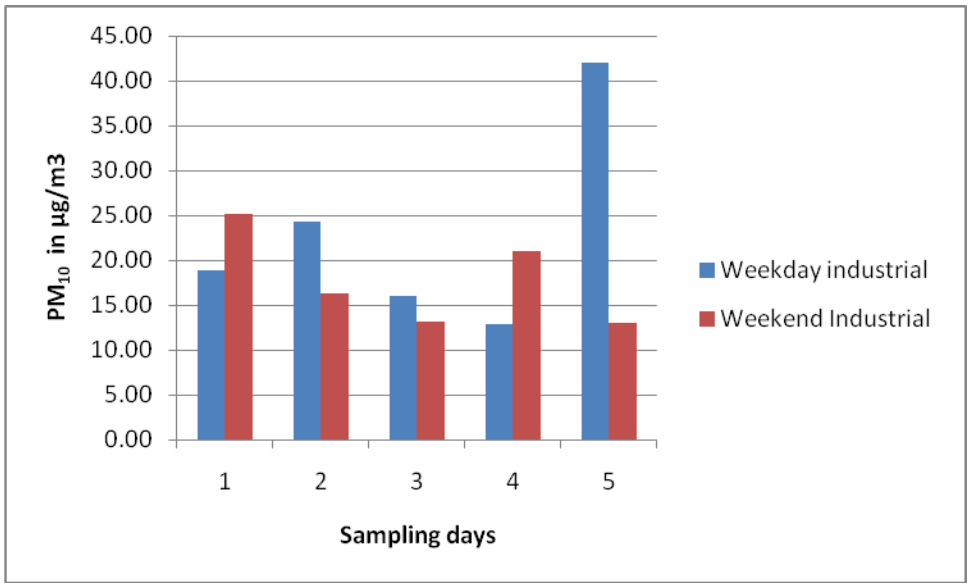

Figure14: Concentration of PM_{10} in Air (Weekday /Weekend) at Industrial site

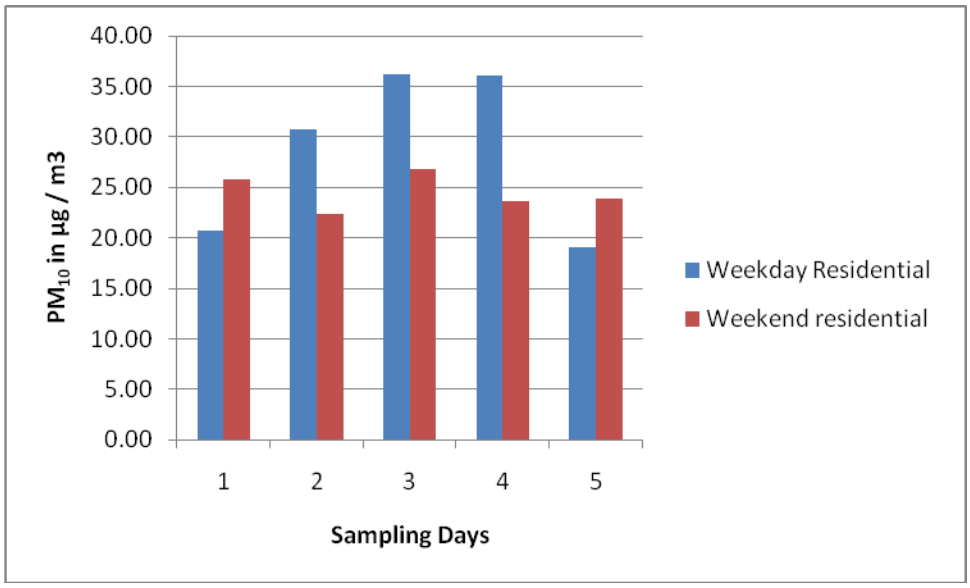

Figure15: Concentration of PM_{10} in Air (Weekday /Weekend) at Residential site

Table 6: PM_{10} in Air at Different Monitoring Sites

Sampling Site	Sampling Days	PM_{10} (µg/m3)
Industrial	20-01-2011	18.87
Industrial	23-01-2011	25.20
Industrial	30-01-2011	16.30
Industrial	20-02-2011	13.19
Industrial	23-02-2011	24.25
Industrial	27-02-2011	21.05
Industrial	04-03-2011	16.08
Industrial	18-03-2011	12.82
Industrial	19-03-2011	13.06
Industrial	23-03-2011	42.01
Residential	26-03-2011	25.74
Residential	31-03-2011	20.76
Residential	05-04-2011	30.74
Residential	09-04-2011	22.34
Residential	16/04/2011	26.87
Residential	18/04/2011	36.20
Residential	21/04/2011	36.11
Residential	23/04/2011	23.65
Residential	28/04/2011	19.05
Residential	30/04/2011	23.91

Table 7: Total Suspended Particle (TSP) in Air at Different Monitoring Sites

Sampling Site	Sampling days	TSP (µg/m3)
Industrial	20-01-2011	134.56
Industrial	23-01-2011	159.31
Industrial	30-01-2011	154.17
Industrial	20-02-2011	136.88
Industrial	23-02-2011	165.42
Industrial	27-02-2011	200.88
Industrial	04-03-2011	148.75
Industrial	18-03-2011	131.86
Industrial	19-03-2011	195.83
Industrial	23-03-2011	201.72
Residential	26-03-2011	162.50
Residential	31-03-2011	89.12
Residential	05-04-2011	157.41
Residential	09-04-2011	152.55
Residential	16/04/2011	133.56
Residential	18/04/2011	193.06
Residential	21/04/2011	225.93
Residential	23/04/2011	146.76
Residential	28/04/2011	131.48
Residential	30/04/2011	196.53

5.2 XRD Results

Table 8 : Basic parameters for XRD

Anchor Scan Parameters	
Sample Identification:	Sample “mayank “
Comment:	Philips Analytical X-Ray B.V.
Comment:	PC-APD, Diffraction software
Measurement Date / Time:	1/1/2002 1:38
Raw Data Origin:	PHILIPS-binary (scan) (.RD)
Scan Axis:	Gonio
Start Position [°2Th.]:	20.01
End Position [°2Th.]:	69.99
Step Size [°2Th.]:	0.02
Scan Step Time [s]:	0.5
Scan Type:	CONTINUOUS
Offset [°2Th.]:	0
Divergence Slit Type:	Fixed
Divergence Slit Size [°]:	0.5
Irradiated Length [mm]:	10
Specimen Length [mm]:	10
Receiving Slit Size [mm]:	0.2
Measurement Temperature [°C]:	0
Anode Material:	Cu
Generator Settings:	40 kV, 55 mA
Diffractometer Type:	PW3710
Diffractometer Number:	1
Goniometer Radius [mm]:	173
Dist. Focus-Diverg. Slit [mm]:	91
Incident Beam Monochromator:	No
Spinning:	No

SAMPLE 1: Graphics

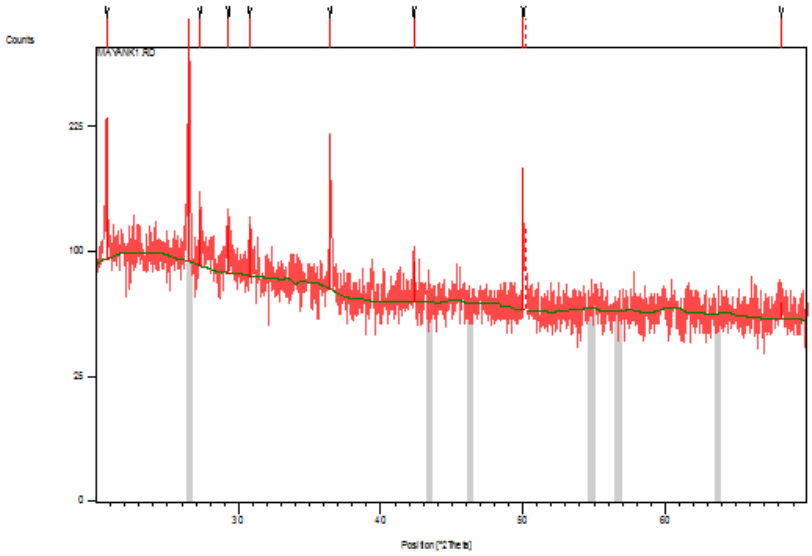

Figure 16: XRD of sample 1

Table 9: XRD result of sample 1

Visible Ref.Code	Score	Compound Name	Fac. Chem.	Formula
26-1079	28	Graphite-3\ITR\RG,..	0.551	C

SAMPLE 2:Graphics

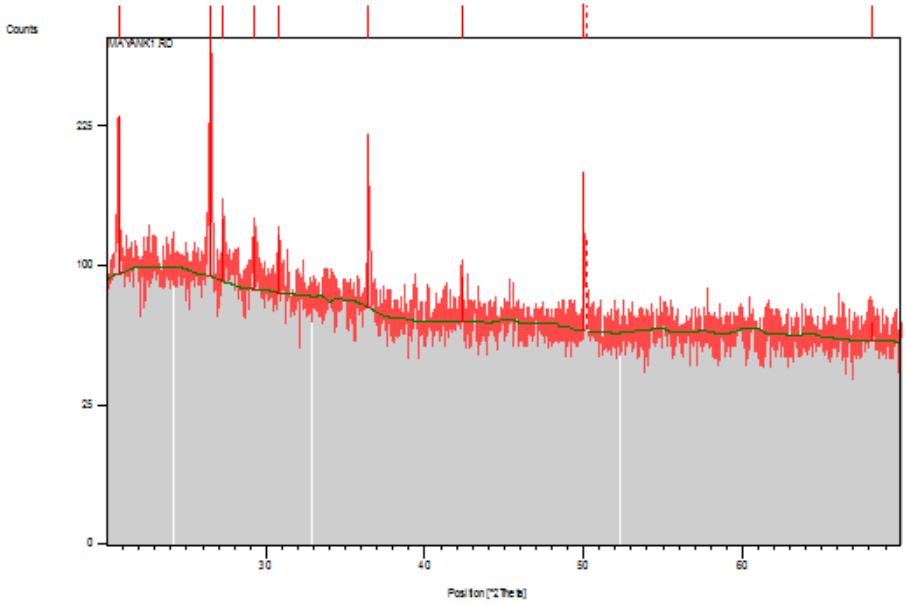

Figure 17 : XRD of sample 2

Table 10: XRD result of sample 2

Pattern List				
Visible Ref.Code	Score	Compound Name	Scale Fac.	Chem. Formula
26-1079	28	Graphite-3\ITR\RG,..	0.551	C
47-0787	41	buckminsterfullerene	0.947	C60
75-1548	11	Carbon Oxide	0.085	CO_2
72-0157	29	Nitrogen	0.249	N_2
05-0428	7	Sulfur Oxide	1.125	SO_2
78-1888	4	Sulfur	0.739	S_8
23-1301	10	Phosphorus Oxide	0.082	P_2O_5
73-1889	7	Phosphorus Oxide	1.178	P_4O_6
79-0603	7	Zeolite EU-1 - art..	0.679	SiO_2

SAMPLE 3: Graphics

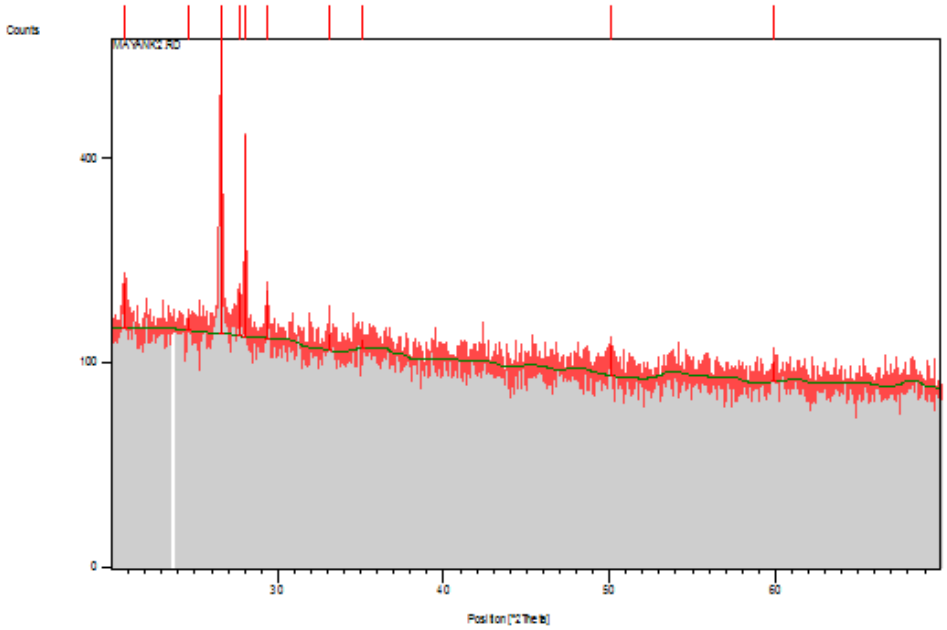

Figure 18 : XRD of sample 3

Table 11 : XRD result of sample 3

Pattern List				
Visible Ref.Code	Score	Compound Name	Scale Fac.	Chem. Formula
75-2078	40	Graphite	0.927	C
44-0558	26	buckminsterfullerene	0.203	C60
48-1449	11	Carbon	0.153	C70
73-0229	19	Oxygen	0.125	O_2
75-1540	14	Carbon Oxide	0.055	CO_2
76-2378	0	Carbon Oxide	0	CO
74-1878	14	Phosphorus	0.17	P
73-1889	8	Phosphorus Oxide	0.354	P_4O_6
05-0318	18	Phosphorus Oxide	0.036	P_2O_5
72-0880	6	Phosphorus Oxide	0.154	P_4O_7
83-2469	14	Quartz	0.066	SiO_2
84-0791	0	Zeolite theta-1	0.074	SiO_2
40-0544	0	Nitrogen	0.005	N_2

74-1901	0	Nitrogen Oxide	0.012	N_2O_2
75-1181	0	Nitrogen Oxide	0.023	N_2O_5
73-2057	5	Nitrogen Oxide	0.042	N_2O

SAMPLE 4: Graphics

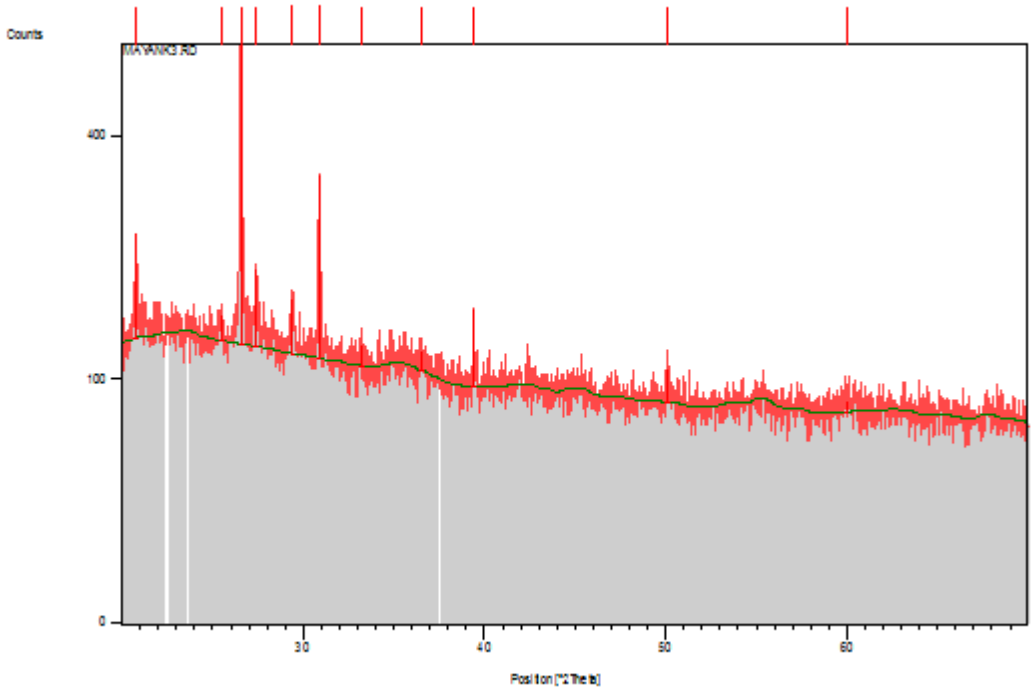

Figure 19: XRD of sample 4

Table 12: XRD result of sample 4

Pattern List				
Visible Ref.Code	Score	Compound Name	Scale Fac.	Chem. Formula
74-0810	26	Nitrogen	0.027	N_2
84-0346	13	Nitrogen Oxide	0.023	N_2O_4
75-1181	0	Nitrogen Oxide	0.033	N_2O_5
47-1374	5	Nitrogen Oxide	0.041	N_2O
08-0415	27	Graphite	0.127	C
47-0787	32	buckminsterfullerene	0.231	C60
72-2091	19	Carbon	0.111	C8
73-0589	24	Carbon Oxide	0.224	CO_2

45-0912	3	Oxygen	5.698	O_2
76-2378	5	Carbon Oxide	0.093	CO
79-1906	52	Quartz	0.298	SiO_2
46-0570	7	Silicon Oxide	0.19	$Si_{24}O_{48}$
72-0984	6	Phosphorus Oxide	0.544	P_4O_7
76-1959	0	Phosphorus	0.02	P

SAMPLE 5: Graphics

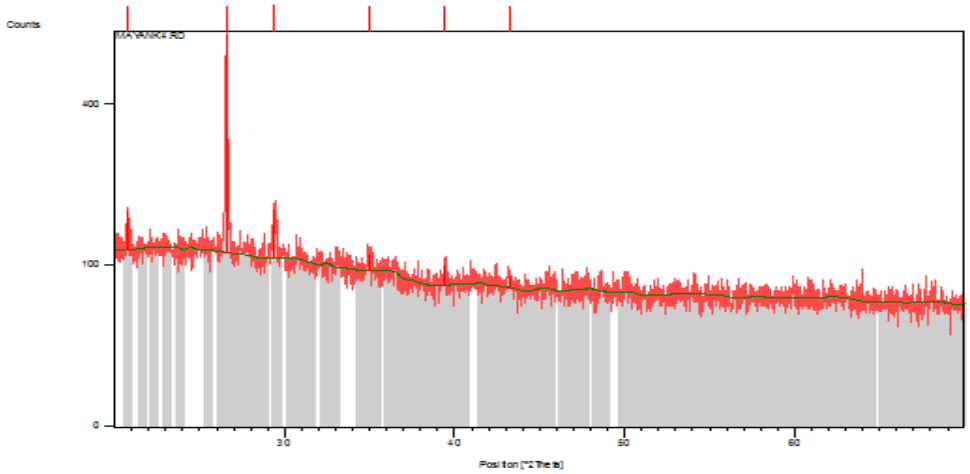

Figure 20: XRD of sample 5

Table 13 : XRD result of sample 5

Pattern List

Visible Ref.Code	Score	Compound Name	Scale Fac.	Chem. Formula
26-1079	44	Graphite-3\ITR\RG,..	1	C
47-0787	27	buckminsterfullerene	0.089	C60
73-0229	28	Oxygen	0.125	O_2
03-0475	7	Carbon Oxide	0.044	CO_2
01-0213	6	Phosphorus Oxide	0.07	P_2O_5

83-0539	52	Quartz	0.958	SiO_2
72-1426	9	Silicon	0.069	Si
70-1366	0	Hydrazine Hydride	0.035	N_2H_5H
73-0588	9	Nitrogen Oxide	0.034	N_2O
40-0544	4	Nitrogen	0.039	N_2
75-1181	6	Nitrogen Oxide	0.104	N_2O_5

5.3 Discussion

There is a large variation in the concentration of ammonia. The average emission of ammonia on weekday at industrial site is more when compared with weekend and average emission of ammonia on weekend at residential site is more when compared with weekday. In nitrogen dioxide, the concentration is always more in weekends, whether it is a residential site or industrial site. On average bases, the concentration of sulfur dioxide is more on weekday, but the values of residential site and industrial site doesn't have a large difference in these values. In carbon monoxide the weekend concentration is always more, whether it is a residential site or industrial site. In Total suspended particles, there is not much difference in the concentration of residential site and industrial site. For PM_{10}, weekday concentration is more for residential site but for industrial site weekend concentration is more than weekday.

CHAPTER 6

CONCLUSION

Ambient air quality of the selected industrial and residential sites have been assessed in Rourkela (Orissa). The study has clearly revealed the levels of air pollutants for TSP, PM_{10}, NO_2, NH_3 , CO and SO_2.The study concludes that an average weekday concentration of major gaseous & particulate pollutants are higher than weekend. Particulate matters have high level of pollution, so it needs to be controlled for the safe survival .

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